

## **Odonata fauna of Sri Lanka: research state and threat status**

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### **ABSTRACT**

Altogether 116 odonate species are known from Sri Lanka. The level of endemism is high – 53 taxa or 45.7% are confined to the island. The Chlorocyphidae, Euphaeidae, Protoneuridae, Platystictidae, Gomphidae and Corduliidae consist of almost exclusively endemic taxa. The odonate fauna of Sri Lanka is still insufficiently known. Knowledge on distribution, biology and taxonomy of adults and especially larval forms is very poor. An assessment of threat status showed that it is very endangered due to habitat destruction. A list of 47 endangered odonate taxa has been compiled. It consists of exclusively endemic taxa and comprises more than 80% of described species confined to the island. Altogether 20 species are preliminary put in the IUCN categories ‘extinct’ (EX) and ‘critically endangered’ (CR) and are urgently proposed for inclusion in the IUCN Red List. Future odonatological research priorities and recommendations are given. Special attention should be devoted to the work dealing with taxonomy of larval forms and adults. Serious faunistic mapping should cover the whole island and should be focused on still preserved areas. Simultaneously also the research of biology of selected species and research of seasonal phenology of adult Odonata should be carried out. Effective nature conservation measures in declared protected areas as well as the establishment of new protected areas and corridors in the Wet zone is of biggest importance for effective long-term preservation of a rich endemic fauna and flora of Sri Lanka, including odonates.

### **SHORT GEOGRAPHIC OUTLINE**

The pear-shaped island of Sri Lanka – or formerly Ceylon – has an area of nearly 66,000 km<sup>2</sup> and is a detached part of the continental Indian plateau of ancient crystalline rocks. It is situated between longitudes 79°39' and 81°53'E and latitudes 5°54' and 9°52'N. The relief of Sri Lanka may be subdivided into three peneplains with average altitudes of 30 m, 500 m and 1,500-1,800 m. The latter two peneplains form the Central Highlands, a complex of plateaus, mountain chains, massifs and basins in the southern half of the island. The highlands are surrounded by vast

plains, which extend from the coast inland and rise to 100-150 m above sea level. As far as the climate of Sri Lanka is concerned, there are only slight variations in temperature, air humidity and day length. The island is commonly subdivided into two climatic subregions, referred to as the Dry and Wet zones. The Wet zone has a typical rainforest climate and there is always some rain. In June, July and August the south-west monsoon greatly affects the climate in the south-western and the central part of the island, while the north-eastern monsoon in December, January and February brings rain to the north-eastern lowland of the dry zone and minor parts of the adjoining central highlands. The average annual rainfall thus varies from more than 5,000 mm in the tropical south-western part of the island to about 1,000 mm on the north-west coast. Because of the very strong evaporation and seasonal rainfalls, a considerable part of the Dry zone suffers from drought and depends on artificial water storage for cultivation. For this purpose, especially in the Dry zone, over 12,000 irrigation reservoirs, which vary from 10 - 7,000 ha and cover an area of over 175,000 ha, have been created.

With more than 50% forest cover in the 1950s Sri Lanka was well above the world average and above the average for the Asian countries. In the end of the 1980s the figure was only slightly over 20% of 'natural' forest cover, what amounts between 12,000 - 17,000 km<sup>2</sup>. Relatively large continuous patches of dry lowland forest are still left in the north-western, north-eastern and south-eastern parts of the island. In the contrary, the biologically and also odonatologically most interesting wet zone, which measures 22,500 km<sup>2</sup>, has only 9% of the surface covered by natural rainforests. Out of that only about 445 km<sup>2</sup> are thought to be undisturbed, what represents only 2% of the original extent (Mittermeier et al. 2000).

## STATE OF THE ART

### An overview of past odonate research

The odonatological research in Sri Lanka has a very long tradition. The very first contribution to the knowledge of the island's Odonata was made by E. de Selys-Longchamps and H.A. Hagen in the middle of the 19th century. Although their work has been continued by several recognized odonatologists, e.g. B.W.F. Kirby, F.F. Laidlaw, F.C. Fraser, M.A. Lieftnick and D. St. Quentin, in the last years it became very clear that our knowledge of the odonate fauna of Sri Lanka is still very incomplete.

Famous odonate manuals published by Fraser (1933c, 1934, 1936) are still very relevant for the odonatological research in Sri Lanka. However, it has to be mentioned that Sri Lanka is one of the few Asian countries, which have a book on its odonate fauna – titled "Dragonflies of Sri Lanka" (Fonseka 2000). It represents a first and comprehensive overview of many different odonatological aspects, ranging from history of odonatological research, compilation of the known species descriptions, determination keys for adults and larvae, summary of distributional records, notes on ecology, etc. Despite some deficiencies and gaps it represents an important milestone in odonatological research in Sri Lanka and will surely stimulate further work on the topic.

For the past nine years I was involved in the study of odonate fauna of Sri Lanka as this was the main subject of my graduation thesis (Bedjanič 1998). In this work all published information on each particular odonate taxon has been systematically gathered and together with the results of my fieldwork in January and February 1995 compiled to a synopsis of the odonate fauna of Sri Lanka. In this way an analysis of the present knowledge of the odonate fauna of Sri Lanka as well as a preliminary analysis of adult odonate phenology was made possible. After 1995, additional fieldwork was carried out in October-November 2001 as well as in April-May 2003 and some articles on the topic were published (Bedjanič 1999, 2000, 2001, 2002a; Bedjanič & Šalamun 2002).

### Research state of odonate fauna

According to the present knowledge altogether 116 Odonata species from 12 families occur in Sri Lanka. Zoogeographical analysis of the odonate fauna of Sri Lanka shows similarity with that of South India. However, 53 taxa (45.7%) are confined to the island. The percentage of endemism is very high in the families Chlorocyphidae, Euphaeidae, Platystictidae, Protoneuridae, Gomphidae and Corduliidae (Fig. 1). More than half of all endemic species show no near relation to south Indian taxa. Some species, viz *Sinhalestes orientalis*, *Anisogomphus solitaris*, *Cyclogomphus gynostylus* and *Microgomphus wijaya* seem not to have any known near allies and are taxonomically isolated. During my research carried out in 2001 and 2003 at least four new endemic species were discovered. They will be described in near future, however, with the exception of Table 2 they are left out of consideration in the present article.

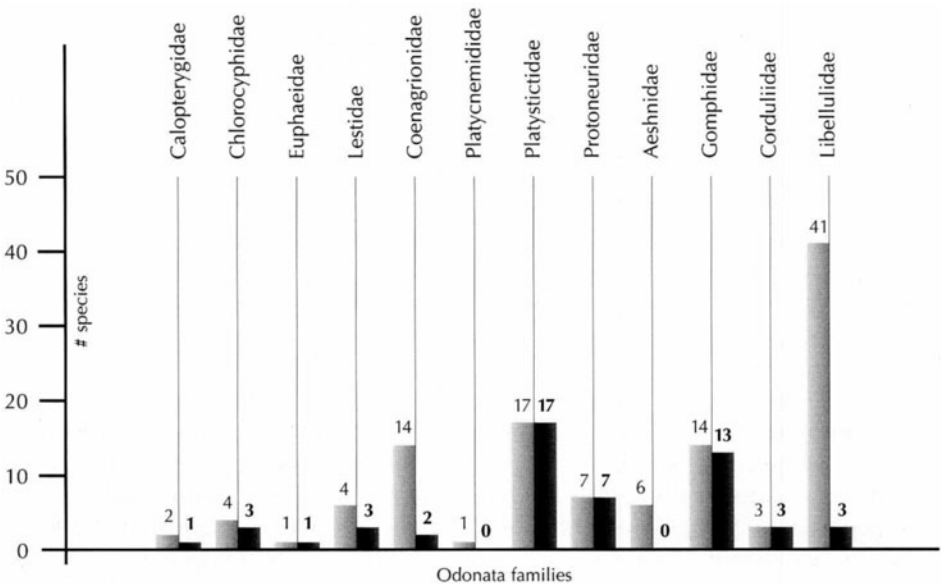


Figure 1: Endemism of the Odonata fauna of Sri Lanka. Total number of odonate species (grey columns) and number of endemic species (black columns), sorted by families.

To gain a better overview of the present knowledge of odonate fauna of Sri Lanka the published data for all species and subspecies were analysed in order to evaluate their research state and arranged in different categories (Table 1). Practically all species in the given categories are confined to Sri Lanka and this fact definitely has also 'global' importance from the biodiversity conservation point of view. The following comments relate to the categories in Table 1; unpublished results of my research carried out in October-November 2001 as well as in April-May 2003 are not considered:

Category I: The group of the species in which one sex has not been described yet consists of only endemic taxa. Mostly the females are still undescribed – they are not so often seen at waters, their behaviour is less known, they are taxonomically insufficiently known and therefore difficult to determine.

Category II & III: About one quarter of the species which occur in Sri Lanka has been found on only a few localities and the records were documented only by a very limited number of specimens. Also this category consists of exclusively endemic taxa. This information clearly indicates very poor faunistical research state of odonate fauna of Sri Lanka and in some cases should not be interpreted as actual rareness of the species.

Category IV: To the group of species in which larval stages or exuviae have not been described yet, not less than 70 species and subspecies or 60.3% of the odonate fauna of Sri Lanka can be designated. This information is very important since records of larvae and exuviae clearly indicate the development of the species in particular habitat. For the research of ecological requirements of individual species, which forms a basis for the effective species conservation measures, the correct determination of larvae or exuviae is of crucial importance.

Category V: Some species, e.g. *Sinhalestes orientalis*, *Heliogomphus ceylonicus* and *H. nietneri*, have not been found since their description, for more than 120 years. All species in this category are very rare and endangered or even extinct and deserve special attention in the future.

From the above analysis the following important conclusions can be made:  
The odonate fauna of Sri Lanka is insufficiently known.

The fact, that almost 65% or 75 species and subspecies are included in at least one category is self-explaining.

As far as Odonata are concerned the special attention in the future should be devoted to projects dealing with taxonomy of larval forms and adults in direct connection with serious faunistic mapping.

In whole South and South-east Asia more attention should be devoted to the description of larval forms and exuviae. At the moment not a single zygopteran larval form of mostly endemic Sri Lankan representatives of the families Chlorocyphidae, Lestidae, Platystictidae and Protoneuridae is known. With the exception of St. Quentin (1973) who, however, gives only little taxonomy data, not a single article, dealing with the odonate fauna of the island is focused on larval forms. The available descriptions that can be found in Fraser (1933b) Lieftinck (1940, 1971) and Bedjanič (2000) are summarized by Fonseca (2000). They have to be therefore considered as more or less accidental.

Table 1. Research state of the Odonata fauna of Sri Lanka. In each category the number of taxa and their proportion to all taxa known for Sri Lanka is given. All species, except those with an asterisk, are endemic to the island. — Category I: Species in which male or female are undescribed so far: 14 taxa; 12.1%; II: Species with max. 10 known adult specimens: 27 taxa; 23.3%; III: Species known from maximal three localities: 30 taxa; 25.9%; IV: Species still lacking description of larval stages or exuvia: 70 taxa; 60.3%; V: Species not found for more than 50 years: 16 taxa; 13.8%.

Family/species	category: I	II	III	IV	V
<b>Chlorocyphidae</b>					
<i>Libellago adami</i> Fraser, 1939	○	○	○	●	○
<i>finalis</i> (Hagen, 1869)	○	○	○	●	○
<i>greeni</i> (Laidlaw, 1924)	○	○	○	●	○
<i>lineata indica</i> (Fraser, 1928)	○	○	○	●	○
<b>Lestidae</b>					
<i>Indolestes divisus</i> (Hagen, 1862)	○	○	○	●	○
<i>gracilis gracilis</i> (Hagen, 1862)	○	○	○	●	○
<i>Lestes elatus</i> Hagen, 1862*	○	○	○	●	○
<i>malabaricus</i> Fraser, 1929*	○	○	○	●	○
<i>praemorsus decipiens</i> Kirby, 1894*	○	○	○	●	○
<i>Sinhalestes orientalis</i> (Hagen, 1862)	○	●	●	●	●
<b>Coenagrionidae</b>					
<i>Aciagrion occidentale</i> Laidlaw, 1919*	○	○	○	●	○
<i>Ceriagrion cerinorubellum</i> (Brauer, 1865)*	○	○	○	●	○
<i>Enallagma parvum</i> Selys, 1876*	○	○	○	●	○
<i>Mortonagrion ceylonicum</i> Lieftinck, 1971	●	●	●	●	○
<i>Onychargia atrocyana</i> Selys, 1865*	○	○	○	●	○
<i>Paracercion malayanum</i> (syn. <i>Cercion</i> ) (Selys, 1876)*	○	○	○	●	○
<i>Pseudagrion malabaricum</i> Fraser, 1924*	○	○	○	●	○
<i>rubriceps ceylonicum</i> (Kirby, 1891)	○	○	○	●	○
<b>Platystictidae</b>					
<i>Drepanosticta adami</i> (Fraser, 1933)	○	●	●	●	●
<i>austeni</i> Lieftinck, 1940	○	●	●	●	●
<i>brincki</i> Lieftinck, 1971	○	●	●	●	○
<i>digna</i> (Selys, 1860)	○	○	●	●	○
<i>fraseri</i> Lieftinck, 1955	●	●	●	●	○
<i>hilaris</i> (Hagen, 1860)	○	●	●	●	●
<i>lankanensis</i> (Fraser, 1931)	○	○	○	●	○
<i>montana</i> (Hagen, 1860)	○	●	●	●	●
<i>nietneri</i> (Fraser, 1931)	○	○	○	●	○
<i>sinhalensis</i> Lieftinck, 1971	●	●	●	●	○
<i>starmuehlneri</i> St. Quentin, 1972	●	●	●	●	○
<i>submontana</i> (Fraser, 1933)	●	●	●	●	●
<i>subtropica</i> (Fraser, 1933)	○	○	●	●	○
<i>tropica</i> (Hagen, 1860)	○	○	○	●	○
<i>walli</i> (Fraser, 1931)	○	●	●	●	○
<i>Platysticta apicalis</i> Kirby, 1894	○	○	○	●	○
<i>maculata</i> Hagen, 1860	○	○	○	●	○

Family/species	category:	I	II	III	IV	V
<b>Protoneuridae</b>						
<i>Disparoneura ramajana</i> Lieftinck, 1971		●	●	●	●	○
<i>Elatoneura bigemmata</i> Lieftinck, 1971		○	○	●	●	○
<i>caesia</i> (Hagen, 1860)		●	○	○	●	○
<i>centralis</i> (Hagen, 1860)		○	○	○	●	○
<i>leucostigma</i> (Fraser, 1933)		○	○	●	●	●
<i>tenax</i> (Hagen, 1860)		○	○	○	●	○
<i>Prodasineura sita</i> (Kirby, 1894)		○	○	○	●	○
<b>Aeshnidae</b>						
<i>Anaciaeschna donaldi</i> Fraser, 1922*		○	○	○	●	●
<i>Anax indicus</i> Lieftinck, 1942*		○	○	○	●	○
<i>Gynacantha</i> sp. indet.		○	○	○	●	○
<b>Gomphidae</b>						
<i>Anisogomphus solitaris</i> Lieftinck, 1971		●	●	●	○	○
<i>Burmagomphus pyramidalis sinuatus</i> Fraser, 1933		○	●	○	○	○
<i>Cyclogomphus gynostylus</i> Fraser, 1926		○	●	●	●	○
<i>Gomphidia pearsoni</i> Fraser, 1933		●	●	●	●	●
<i>Heliogomphus ceylonicus</i> (Selys, 1878)		●	●	●	●	●
<i>lyratus</i> Fraser, 1933		○	●	●	●	●
<i>nietneri</i> (Selys, 1878)		●	●	●	●	●
<i>walli</i> Fraser, 1925		○	●	●	●	●
<i>Macrogomphus annulatus keiseri</i> Lieftinck, 1955		●	●	●	●	
<i>lankanensis</i> Fraser, 1933		○	●	●	●	●
<i>Megalogomphus ceylonicus</i> (Laidlaw, 1922)		○	●	●	○	●
<i>Microgomphus wijaya</i> Lieftinck, 1940		○	●	●	○	●
<b>Corduliidae</b>						
<i>Macromia flinti</i> Lieftinck, 1977		●	●	●	●	○
<i>zeylanica</i> Fraser, 1927		●	●	○	○	○
<b>Libellulidae</b>						
<i>Cratilla lineata calverti</i> Förster, 1903*		○	○	○	●	○
<i>Hydrobasileus croceus</i> (Brauer, 1867)*		○	○	○	●	○
<i>Hylaeothemis fruhstorferi</i> (Karsch, 1889)		○	○	●	●	●
<i>Indothemis carnatica</i> (Fabricius, 1798)*		○	○	○	●	○
<i>limbata sita</i> Campion, 1923*		○	○	○	●	○
<i>Lathrecista a. asiatica</i> (Fabricius, 1798)*		○	○	○	●	○
<i>Macrodiplax cora</i> (Kaup, 1867)*		○	○	○	●	○
<i>Onychothemis tonkinensis ceylanica</i> Ris, 1912*		○	○	○	●	○
<i>Orthetrum chrysis</i> (Selys, 1891)*		○	○	○	●	○
<i>glaucum</i> (Brauer, 1865)*		○	○	○	●	○
<i>luzonicum</i> (Brauer, 1868)*		○	○	○	●	○
<i>t. triangularis</i> (Selys, 1878)*		○	○	○	●	○
<i>Palpopleura s. sexmaculata</i> (Fabricius, 1787)*		○	○	○	●	○
<i>Rhyothemis triangularis</i> Kirby, 1889*		○	○	○	●	○
<i>Tetrathemis yerburii</i> Kirby, 1894		○	○	○	●	○
<i>Trithemis pallidinervis</i> (Kirby, 1889)*		○	○	○	●	○

It is obvious that at present we know very little about the Odonata of Sri Lanka. There is practically no relevant information on the biology and ecology of endemic representatives. Also our knowledge on taxonomy and distribution has great gaps.

### THREAT STATUS OF THE ODONATE FAUNA OF SRI LANKA

Not a single odonate species from Sri Lanka is included in the global IUCN Red List of threatened species (IUCN 2003). So far only one species, viz *Sinhalestes orientalis* has been placed on the “prestigious” world list of Odonata taxa to which special attention should be devoted in the following years (Moore 1997).

Unfortunately there are many additional ones which would deserve such status and should be declared as priority species for future investigations. This is imperative since the endemic odonate fauna of Sri Lanka is very endangered and some very interesting taxa are threatened with extinction.

The main reason for this is rapid destruction of primary rainforest, which has grown in last decades to a nature catastrophe. In the middle of 20th century more than 50% of Sri Lanka was covered with forest but only thirty years later the percentage has fallen to around 20%. Impoundment, extraction for irrigation and careless pollution of rivers and streams, together with other pressures on flowing waters, have brought mostly endemic species to or even over the brink of extinction. Factors as high population growth followed by urbanisation and acute shortage of land – Sri Lanka has nearly 19 million inhabitants and a population density over 270 people per km<sup>2</sup> –, mining, soil erosion and environment pollution result in additional habitat loss and affect fauna and flora both directly and indirectly. It may look surprising but around 12% of the island is within different forms of protected areas, ranging from biosphere reserves and national parks, nature reserves, forest reserves, wildlife sanctuaries etc. Unfortunately, there is a complete lack of systematically gathered information on the odonate fauna of existing protected areas in Sri Lanka and not a single professional study on this topic has ever been made. In this situation we can only guess to which extent the existing protected areas really ensure the long-term conservation of Odonata.

Despite the fact that the proportion of protected areas in Sri Lanka is relatively high they are mainly located in the lowlands of Dry zone because of the historically strong attachment of official nature conservation towards elephants, leopards and other big animals. According to the hereto collected data, only a small proportion of endemic odonate taxa inhabit Dry zone forests as well as lowland rivers and numerous water tanks in this areas. The speculation that some endemic species

Comments on Table 1: There are additional species, whose occurrence on Sri Lanka is very poorly known but are elsewhere not rare. In this category following species could be included: *Agriocnemis femina femina* (Brauer, 1868), *Anax ephippiger* (Burmeister, 1839), *Aethria-manta b. brevipennis* (Rambur, 1842) and *Zyxomma petiolatum* Rambur, 1842.

may already be extinct and that many small and isolated Odonata populations are probably on the brink of disappearance is unfortunately very close to reality. In addition, many protected areas are too small for long term survival of endangered species or degraded to the point where they do not harbour natural biodiversity. Even more problematic is the neglect of exceptionally rich fauna and flora of remaining patches of Wet-zone rain forests and their very incomplete inclusion in the protected areas system.

Only recently the nature protection agencies and institutions in Sri Lanka started to recognize odonates as an important part of island's biodiversity. As far as nature protection law is concerned not a single odonate species is mentioned in official "Fauna and Flora Protection Ordinance". On the other hand, in "The 1999 list of threatened fauna and flora of Sri Lanka" (IUCN Sri Lanka 2000), altogether 50 Odonata species are listed as 'threatened' (TR), 20 as 'highly threatened' (HT) and four as 'data deficient' (DD). More or less the same data are presented also in "A comparison of the conservation and legal status of the fauna and flora of Sri Lanka" (IUCN Sri Lanka 2003). Unfortunately, the only basis for the mentioned evaluation of the threat status has been the book by Fonseka (2000), which is not the best source for such task, especially for the non-odonatologist. Despite numerous deficiencies in listing and ranking of single odonate taxa, the general message was stressed quite correctly: the odonate fauna of Sri Lanka with its numerous endemic representatives is very endangered.

In Table 2 an attempt to assess the threat status of the odonate fauna of Sri Lanka has been made. The list of endangered species comprises 47 exclusively endemic taxa, among them also four recently discovered, yet undescribed species. This

Table 2. Endangered endemic odonate species found in Sri Lanka. DD: data deficient; RR: range restricted; IC: identity of species needs clarification; A: action recommended, because of habitat destruction.

Family/species	DD	RR	IC	A	Distribution / habitat and notes
<b>Chlorocyphidae</b>					
<i>Libellago finalis</i> (Hagen, 1869)	●	●	○	●	Rivers and streams in mid hill to mountain areas
<b>Lestidae</b>					
<i>Indolestes divisus</i> (Hagen, 1862)	●	●	○	●	
<i>Sinhalestes orientalis</i> (Hagen, 1862)	●	●	○	●	Not found since description. Monotypic genus, taxonomically isolated, no near allies
<b>Coenagrionidae</b>					
<i>Agriocnemis cf. femina</i> (Brauer, 1868)	●	●	●	●	Rare species of doubtful taxonomic position (see Bedjanič 2002a)
<i>Archibasis</i> sp. nov.	●	●	●	●	Rivulets in the mid-hill primary rainforest and surrounding less disturbed areas. Rare species, discovered in 2001, awaits description
<i>Mortonagrion ceylonicum</i> Lieftinck, 1971	●	●	○	●	Not found since description



Family/species	DD	RR	IC	A	Distribution / habitat and notes
<b>Platystictidae</b>					
<i>Drepanosticta adami</i> (Fraser, 1933)	●	●	○	●	
<i>austeni</i> Lieftinck, 1940	●	●	○	●	Not found since description
<i>brincki</i> Lieftinck, 1971	●	●	○	●	
<i>digna</i> (Selys, 1860)	●	●	○	●	
<i>fraseri</i> Lieftinck, 1955	●	●	●	●	Small streams and springs in rainforest
<i>hilaris</i> (Hagen, 1860)	●	●	○	●	Not found since description
<i>lankanensis</i> (Fraser, 1931)	●	●	○	●	
<i>montana</i> (Hagen, 1860)	●	●	○	●	Not found since description
<i>nietneri</i> (Fraser, 1931)	●	●	○	●	
<i>sinhalensis</i> Lieftinck, 1971	●	●	●	●	
<i>starmuehlneri</i> St. Quentin, 1972	●	●	●	●	
<i>submontana</i> (Fraser, 1933)	●	●	○	●	Not found since description
<i>subtropica</i> (Fraser, 1933)	●	●	○	●	
<i>tropica</i> (Hagen, 1860)	●	●	○	●	Small streams in dense montane forests of mountain regions
<i>walli</i> (Fraser, 1931)	●	●	●	●	
sp. nov. A	●	●	●	●	Streams in mid-hill primary rainforest Rare species, discovered in 2003, seems not to have near allies and awaits description
sp. nov. B	●	●	●	●	Streams in mid-hill primary rainforest Rare species, discovered in 2003, seems not to have near allies and awaits description
<i>Platysticta apicalis</i> Kirby, 1894	●	●	○	●	Streams and rivulets in the mid-hill primary rainforest and surrounding less disturbed areas
<i>maculata</i> Hagen, 1860	●	●	○	●	Streams and rivulets in the mid-hill primary rainforest and surrounding less disturbed areas
<b>Protoneuridae</b>					
<i>Disparoneura ramajana</i> Lieftinck, 1971	●	●	●	●	Dense montane forest of mountain regions. Not found since description
<i>Elatoneura bigemmata</i> Lieftinck, 1971	●	●	○	●	Streams and rivers in the lowland to midhill primary rainforest and some surrounding less disturbed areas
<i>caesia</i> (Hagen, 1860)	●	●	○	●	Streams in mid-hill primary rainforest.
<i>leucostigma</i> (Fraser, 1933)	●	●	○	●	Small streams in dense montane forests of mountain regions Not found since description
<i>tenax</i> (Hagen, 1860)	●	●	○	●	Streams in the mid-hill primary rainforest and surrounding less disturbed areas

Family/species	DD	RR	IC	A	Distribution/Habitat and notes
<b>Gomphidae</b>					
<i>Anisogomphus solitaris</i> Lieftinck, 1971	●	●	●	●	Not found since description. Taxonomic position questionable, no near allies Due to the considerable deviation in adult and larval characters the species most probably may belong to a new genus (Lieftinck, 1971)
<i>Burmagomphus pyramidalis sinuatus</i> Fraser, 1933	●	●	○	●	
<i>Cyclogomphus gynostylus</i> Fraser, 1926	●	●	○	●	Streams and rivers in the mid-hills to lowlands. Taxonomically isolated, no near allies
<i>Gomphidia pearsoni</i> Fraser, 1933	●	●	○	●	Pools of moderately fast to slow flowing streams and rivers in the mid-hill primary rainforest and some surrounding less disturbed areas
<i>Heliogomphus ceylonicus</i> (Selys, 1878)	●	●	●	●	Not found since description Taxonomic position is doubtful
<i>lyratus</i> Fraser, 1933	●	●	○	●	Not found since description
<i>nietneri</i> (Selys, 1878)	●	●	○	●	Not found since description
<i>walli</i> Fraser, 1925	●	●	○	●	Streams and rivers with waterfalls in the mid-hills
<i>Macrogomphus annulatus keiseri</i> Lieftinck, 1955	●	●	○	●	
<i>lankanensis</i> Fraser, 1933	●	●	○	●	
<i>Megalogomphus ceylonicus</i> (Laidlaw, 1922)	●	●	○	●	Streams and rivers in the lowland to mid-hill primary rainforest and some surrounding less disturbed areas
<i>Microgomphus wijaya</i> Lieftinck, 1940	●	●	○	●	Rivers and streams with rich surrounding vegetation in mid-hills
<b>Corduliidae</b>					
<i>Macromia flinti</i> Lieftinck, 1977	●	●	○	●	Not found since description
<i>zeylanica</i> Fraser, 1927	●	●	○	●	Streams and rivers with rich surrounding vegetation in the mid-hill areas
<i>Macromidia</i> sp. nov.	●	●	●	●	Rare species discovered in 2001 and related to <i>M. donaldi</i> (Fraser, 1924) from South India, awaits description
<b>Libellulidae</b>					
<i>Hylaeothemis fruhstorferi</i> (Karsch, 1889)	●	●	○	●	Not found in last 50 years. Related to <i>H. indica</i> Fraser, 1946
<i>Tetrathemis yerburii</i> Kirby, 1894	●	●	○	●	Vegetation along streams and rivers in the mid-hill rainforest. Unusual biology, characteristic oviposition for the genus

means, by other words, that more than 80% of the described endemic odonate taxa are threatened. Almost all endemic representatives of families Platystictidae, Protoneuridae, Gomphidae and Corduliidae are listed. The fact is alarming and definitely has global importance from the biodiversity conservation point of view. Evaluation of threat status of individual species is mainly based on published data. New unpublished data collected by me in 2001 and 2003, as well as unpublished results of intensive collecting carried out in the 1970s by the staff of Smithsonian Institution from USA (M.A. Lieftinck in litt.; J. van Tol pers. comm.) were used in this respect as well. Since the odonate fauna of Sri Lanka is insufficiently known, many of the listed species in Table 2 could automatically be marked as 'data deficient'. From the global point of view, all can also be marked as 'range restricted' species. Their known occurrence is limited almost exclusively to few isolated localities in the Wet and Intermediate zone of Sri Lanka. As far as taxonomy is concerned a revision of the exclusively endemic family Platystictidae with remarkable species radiation is urgently needed. Detailed revision of this family done by Fraser (1933a) has been supplemented by subsequent workers with description of five species (Lieftinck 1940, 1955, 1971; St. Quentin 1972), and recently also some new material was collected by me. A preliminary analysis shows that some taxa of the family Platystictidae from Sri Lanka are still undescribed and others may fall into synonymy.

On the basis of literature data and available unpublished records the following endemic species are preliminary put in the IUCN categories 'extinct' (EX) and 'critically endangered' (CR): *Sinhalestes orientalis*, *Drepanosticta adami*, *D. austeni*, *D. hilaris*, *D. montana*, *D. submontana*, *Elattonneura leucostigma*, *E. caesia*, *Disparoneura ramajana*, *Anisogomphus solitaris*, *Cyclogomphus gynostylus*, *Gomphidia pearsoni*, *Heliogomphus ceylonicus*, *H. lyratus*, *H. nietneri*, *Macrogomphus lankanensis*, *Microgomphus wijaya*, *Macromia flinti*, *Tetrathemis yerburii* and *Hylaeothemis fruhstorferi*. Herewith they are urgently proposed to be included on the IUCN list of globally endangered animals.

It should be stressed that this list is far from being complete and may only represent an incomplete top of the iceberg. Surely some additional endemic species listed in Table 2, as well as some undescribed taxa, are highly endangered and are at the brink of extinction.

## CONSERVATION PRIORITIES AND RECOMMENDATIONS

Effective nature conservation measures in declared protected areas as well as establishment of new protected areas in the Wet zone are of biggest importance and the only way to insure the long-term preservation of a rich endemic fauna and flora of Sri Lanka, including Odonata. Since natural vegetation and habitats are already so disturbed and fragmented, the focus should be set on taking an effective action to stop further encroachment on the wet zone rainforests and establishment of smaller protected areas and corridors between them. Only such "network" could ensure long-term preservation of endemic fauna and flora.

As far as Odonata are concerned, the basic information on biology and distribution of endemic species is still very poor. Therefore it is impossible to suggest any

“single-species-oriented” conservation measures yet. In order to improve our knowledge on the odonate fauna of Sri Lanka special attention in the future should be devoted to projects dealing with taxonomy of larval forms and adults, in connection with serious faunistic mapping and research on the biology of selected odonate species (see below). Only in this way we will be able to effectively assess their conservation status, suggest appropriate conservation measures for the key species as well as to recognise and promote the huge importance of the odonate fauna of Sri Lanka for world science and conservation of biodiversity. Fortunately very high diversity of fauna and flora, especially the number of taxa confined to the island, has already been recognized and there are good reasons to name Sri Lanka one of the “hot-spots” of South and South-east Asia (Mittermeier et al. 2000). In addition, Sri Lankan Moist Forests (Ecoregion 21) and South-western Sri Lanka Rivers and Streams (Ecoregion 172) are included in the prestigious WWF’s global 200 list of the earth’s most biologically outstanding habitats (Olson et al. 2000).

## RESEARCH PRIORITIES AND RECOMMENDATIONS

The odonate fauna of Sri Lanka is very interesting but insufficiently known. Knowledge on distribution, biology and taxonomy is very poor, especially regarding larval forms. Due to the habitat destruction (mainly primary tropical rainforest) the odonate fauna of Sri Lanka is also very endangered – some very interesting or/and endemic taxa are threatened with extinction or are probably already extinct. According to these facts the main Odonata research priorities are as follows:

Special attention in the future should be devoted to the work dealing with taxonomy of larval forms and adults. Expert taxonomic knowledge should be focused especially on description of larval forms and exuviae.

Serious faunistic mapping should cover the whole island. In order to get an overview of conservation status of less widespread and highly endangered endemic species, the research should be focused on protected areas and other still preserved areas without nature conservation status.

Simultaneously also the research of biology of selected species and research of seasonal phenology of adult odonate species should start.

All existing odonatological data (museum collections and literature) should be put in an odonatological database, which would enable overview of present knowledge for each species and generate outputs such as distribution maps etc.

To carry out the suggested measures successfully, some basic conditions have to be fulfilled on local and international level. Above all, mutual cooperation with appropriate nature conservation institutions and experts in Sri Lanka should be built and joint projects should be prepared. As a part of these, a small team of local scientists or students should be trained in Odonata research.

For serious scientific faunistic work, which is inevitably connected with the capture of Odonata and building up museum collections, legal permission has to be issued by appropriate nature conservation authority. It has to be stressed that the capture of

voucher material is substantial for serious odonatological scientific work. In the contrary to the general belief, it does not influence the species' conservation status in any way and is absolutely necessary in order to get reliable and verifiable data. In addition, Odonata are not commercially interesting in the sense of "entomological resale", therefore serious scientific collecting is not problematic from any nature conservation perspective. In any case, a kind of mechanism should be developed, which would ensure easier obtaining of necessary permits for field work on one hand and on the other hand would control the field work in terms of collecting and submitting the results. The IUCN Species Survival Commission – Odonata Specialists Group could act as an important mediator in issuing recommendation based on references of the researcher and could also play an important role in the exchange and evaluation of results.

### CURRENT ODONATOLOGICAL ACTIVITIES AND FUTURE PERSPECTIVE

In last years the interest on the odonate fauna of Sri Lanka has considerably grown. Herewith the book 'Dragonflies of Sri Lanka' (Fonseka 2000) greatly fulfilled its basic purpose. In addition, some popular articles on dragonflies, such as the one written for the widely read nature conservation magazine 'Sri Lanka nature' (De Silva Wijeyeratne 2001), definitely helped to stimulate this aspect. Based on my cooperation with local naturalists and sponsored by the leading Sri Lankan ecotouristic company Jetwing, a small photographic guide to the dragonflies of Sri Lanka has been published recently (De Silva Wijeyeratne et al. 2003). It comprises 88 photographs of 64 odonate species, including many interesting endemic representatives. Odonata photographs and short species descriptions will also form a part of the new popular 'Field guide to birds, butterflies and dragonflies of Sri Lanka', which is scheduled to be published in 2004 in Sinhala and English language. In the frame of activities of ecotouristic company Jetwing, also a special 'Dragonfly Research Project' is being developed, details of which can be found on the Internet <[www.jetwingeco.com](http://www.jetwingeco.com)>. The already mentioned book of T. de Fonseka and recently published photographic field guides will definitely encourage more foreign odonatists to travel to the island and make their research here.

Since my first field trip to the island in 1995 I am involved in the studies of the odonate fauna of Sri Lanka. Up to now a comprehensive graduation thesis (Bedjanič 1998), as well as some articles were published on the topic (Bedjanič 1999, 2000, 2001, 2002a; Bedjanič & Šalamun 2002). Recently, a small booklet 'Dragonflies of Sri Lanka in colour' has been privately published as a draft of a future photographic manual to the odonate fauna of the island (Bedjanič 2002b). In absence of official permits the fieldwork has unfortunately mainly been limited to the non-protected areas, but nevertheless gave very good results. More than 50 localities were visited and more than 70 species were recorded both in 2001 and 2003. Among the recorded species there are some very interesting and even new taxa as well as many so far unknown larval forms. The extent of the latter is surprisingly high, so it will be possible to describe the last larval instars of more than a dozen endemic species. In the almost exclusively endemic family Gomphidae, for

instance, this would mean that only three or four of the currently known species will be without description of the final larval instar. This opens many new possibilities, especially in mapping and studying of larval biology and habitat requirements of selected species.

In conclusion it is worth stressing again that the above analysis is almost exclusively based on published records only. My still unpublished data as well as the unpublished results of the above mentioned investigation of the staff of Smithsonian Institution from USA were only used for the compilation of the list of the most endangered odonate species in Sri Lanka (Table 2). Since not even all existing records were collected yet, one of the first goals in future Odonata research will be the examination of all available museum collections and gathering of individual faunistic data into a database for a 'Distributional atlas of the dragonflies of Sri Lanka'. In this respect the collection in the Smithsonian Institution is only one part of the work, which will have to be continued at least in London, Leiden and Colombo Natural History Museums. With the better knowledge of larval forms also older larval collections in Lund and Vienna Museum will give many new information, not only on distribution of the species but also on their biology. The next very important step will be the inventarisisation of the odonate fauna in all protected areas. Especially reserves and sanctuaries in the Wet and Intermediate zone will surely bring many new Odonata taxa to the light, not to mention the crucial nature conservation overview, namely, to which extent the existing protected areas really ensure the long-term preservation of the extremely interesting endemic odonate fauna.

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